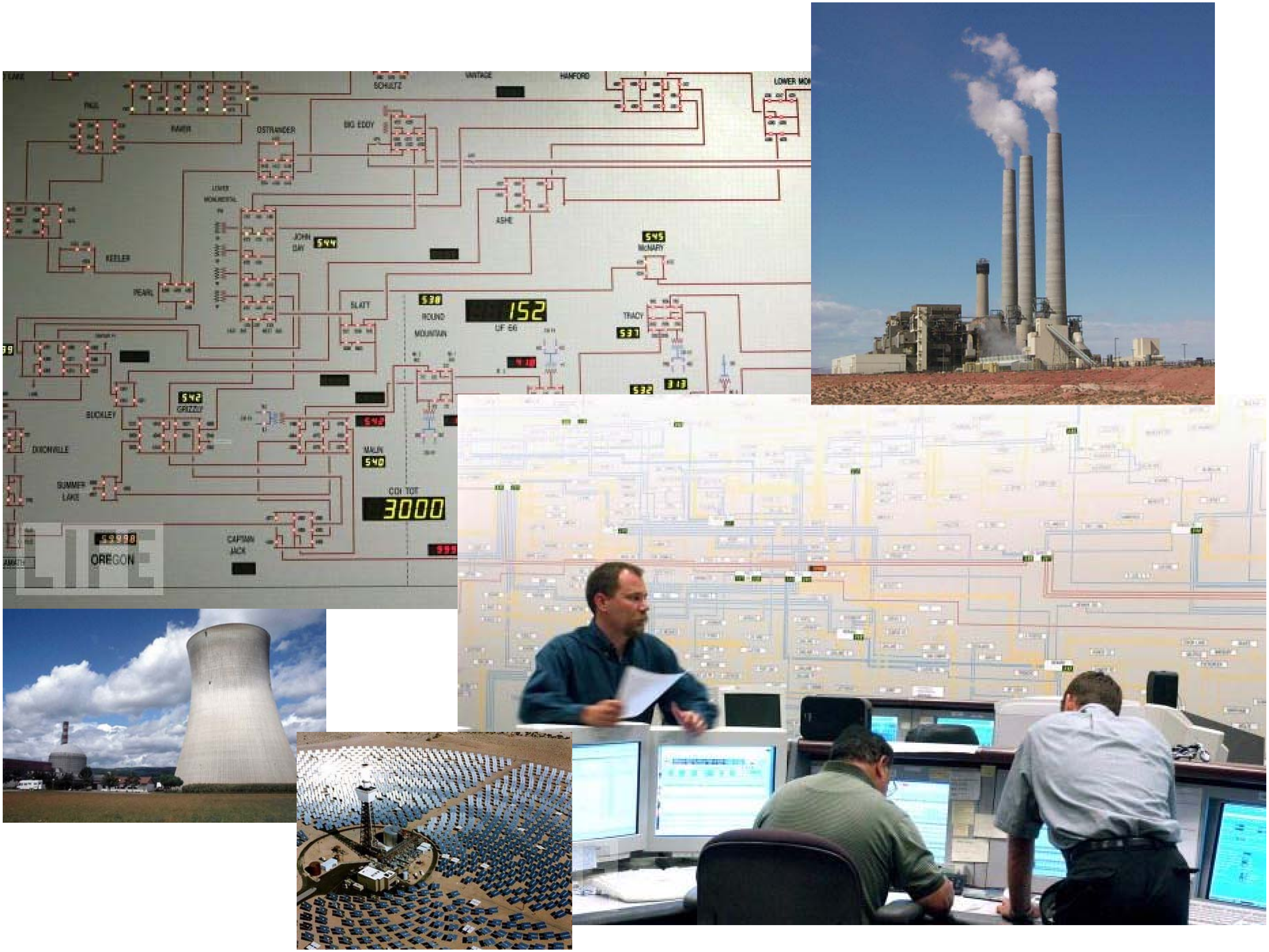
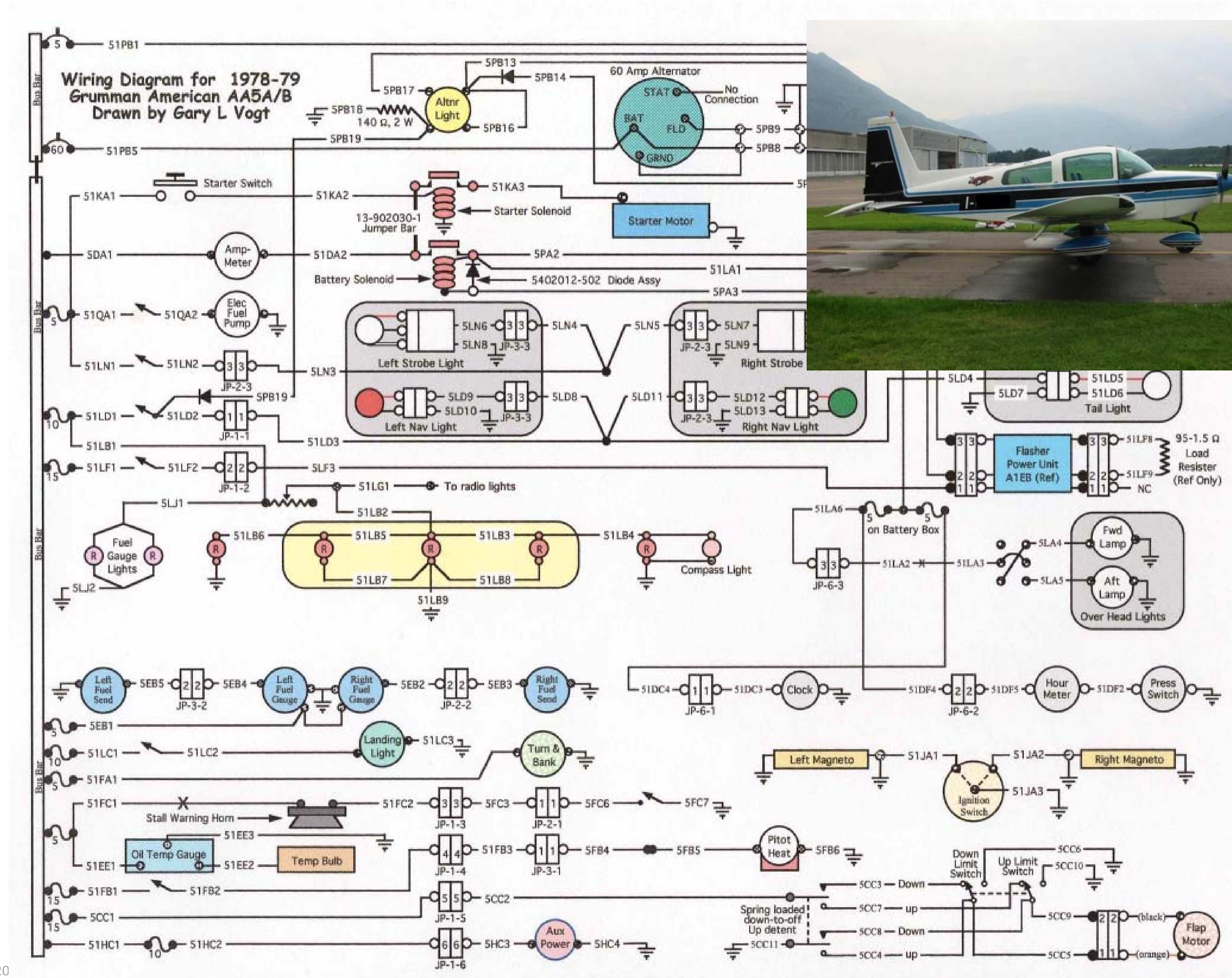
Announcements:

1. Announcements

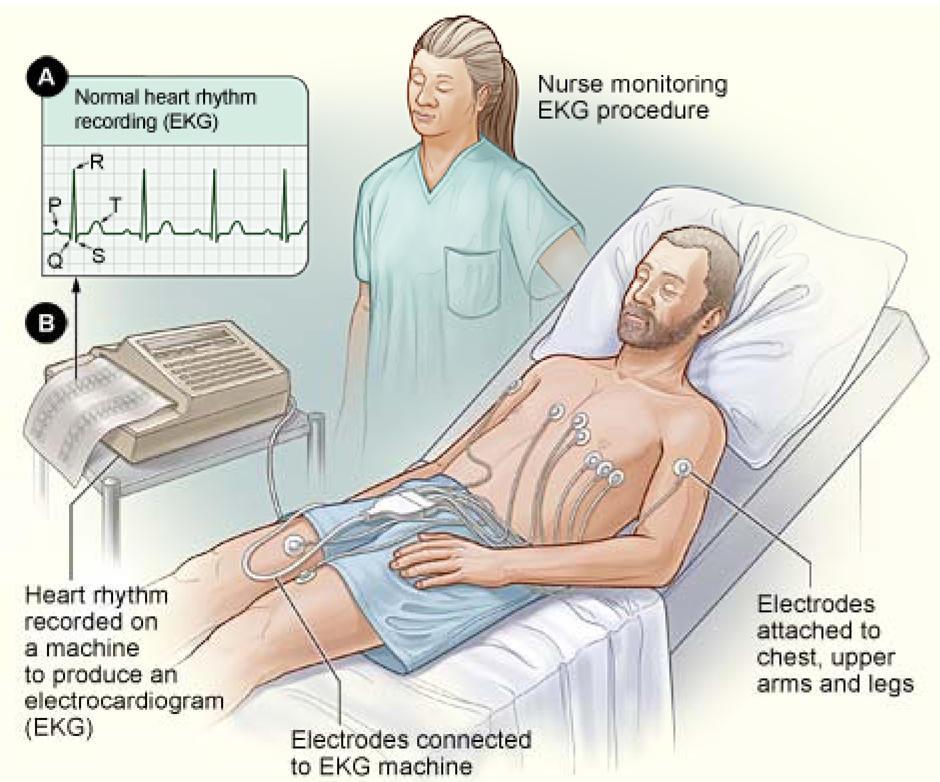
EECS 70A: Network Analysis

Lecture 5

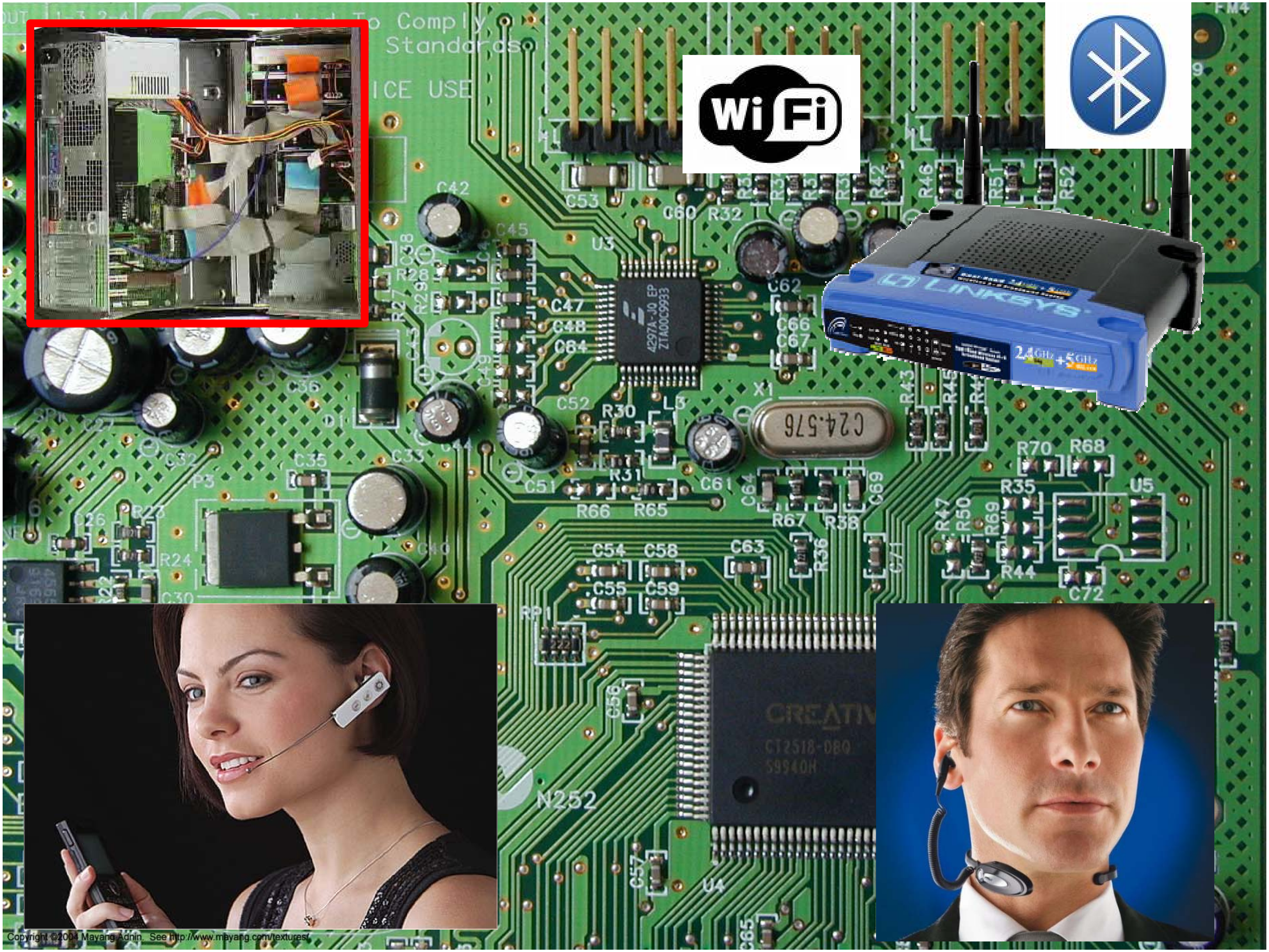

SCHULTZ
VANTAGE
HANFORD
BIG EDDY
OSTRANDER
KEELER
PEARL
JOHN DAY
ASHE
McNARY
SLATT
ROUND MOUNTAIN
152
TRACY
BUCKLEY
GRIZZLY
DIXONVILLE
SUMMER LAKE
MALIN
COI TOT
3000
CAPTAIN JACK
OREGON
LIFE


Wiring Diagram for 1978-79
Grumman American AA5A/B
Drawn by Gary L Vogt
Bus Bar
51PB1
51PB5
5PB13
5PB14
5PB17
5PB18
140 Ω, 2 W
Altnr Light
5PB16
5PB19
60 Amp Alternator
STAT
No Connection
BAT
FLD
GRND
5PB9
5PB8
Starter Switch
51KA1
51KA2
51KA3
Starter Solenoid
13-902030-1 Jumper Bar
Starter Motor
5DA1
Amp-Meter
51DA2
5PA2
Battery Solenoid
51LA1
5402012-502 Diode Assy
5PA3
51QA1
51QA2
Elec Fuel Pump
5LN6
5LN8
JP-3-3
5LN4
5LN5
5LN7
5LN9
JP-2-3
Left Strobe Light
Right Strobe
51LN1
51LN2
JP-2-3
5LN3
5LD9
5LD10
5LD8
5LD11
5LD12
5LD13
Left Nav Light
Right Nav Light
5LD4
5LD7
51LD5
51LD6
Tail Light
51LD1
51LD2
JP-1-1
51LD3
51LB1
51LF1
51LF2
JP-1-2
5LF3
Flasher Power Unit A1EB (Ref)
51LF8
51LF9
NC
95-1.5 Ω Load Resister (Ref Only)
51LG1
To radio lights
51LB2
5LJ1
51LA6
on Battery Box
Fuel Gauge Lights
51LB6
51LB5
51LB3
51LB4
51LB7
51LB8
51LB9
Compass Light
JP-6-3
51LA2
51LA3
5LA4
5LA5
Fwd Lamp
Aft Lamp
Over Head Lights
5LJ2
Left Fuel Send
5EB5
JP-3-2
5EB4
Left Fuel Gauge
Right Fuel Gauge
5EB2
JP-2-2
5EB3
Right Fuel Send
51DC4
JP-6-1
51DC3
Clock
51DF4
JP-6-2
51DF5
Hour Meter
51DF2
Press Switch
5EB1
51LC1
51LC2
Landing Light
51LC3
Turn & Bank
51FA1
Left Magneto
51JA1
51JA2
Right Magneto
51JA3
Ignition Switch
51FC1
Stall Warning Horn
51FC2
JP-1-3
5FC3
JP-2-1
5FC6
5FC7
51EE3
Oil Temp Gauge
51EE1
51EE2
Temp Bulb
JP-1-4
51FB3
JP-3-1
5FB4
5FB5
Pitot Heat
5FB6
51FB1
51FB2
Down Limit Switch
Up Limit Switch
5CC6
5CC10
5CC3 — Down
5CC7 — up
5CC8 — Down
5CC4 — up
Spring loaded down-to-off Up detent
5CC1
JP-1-5
5CC2
5CC9
5CC11
5CC5
(black)
(orange)
Flap Motor
51HC1
51HC2
JP-1-6
5HC3
Aux Power
5HC4

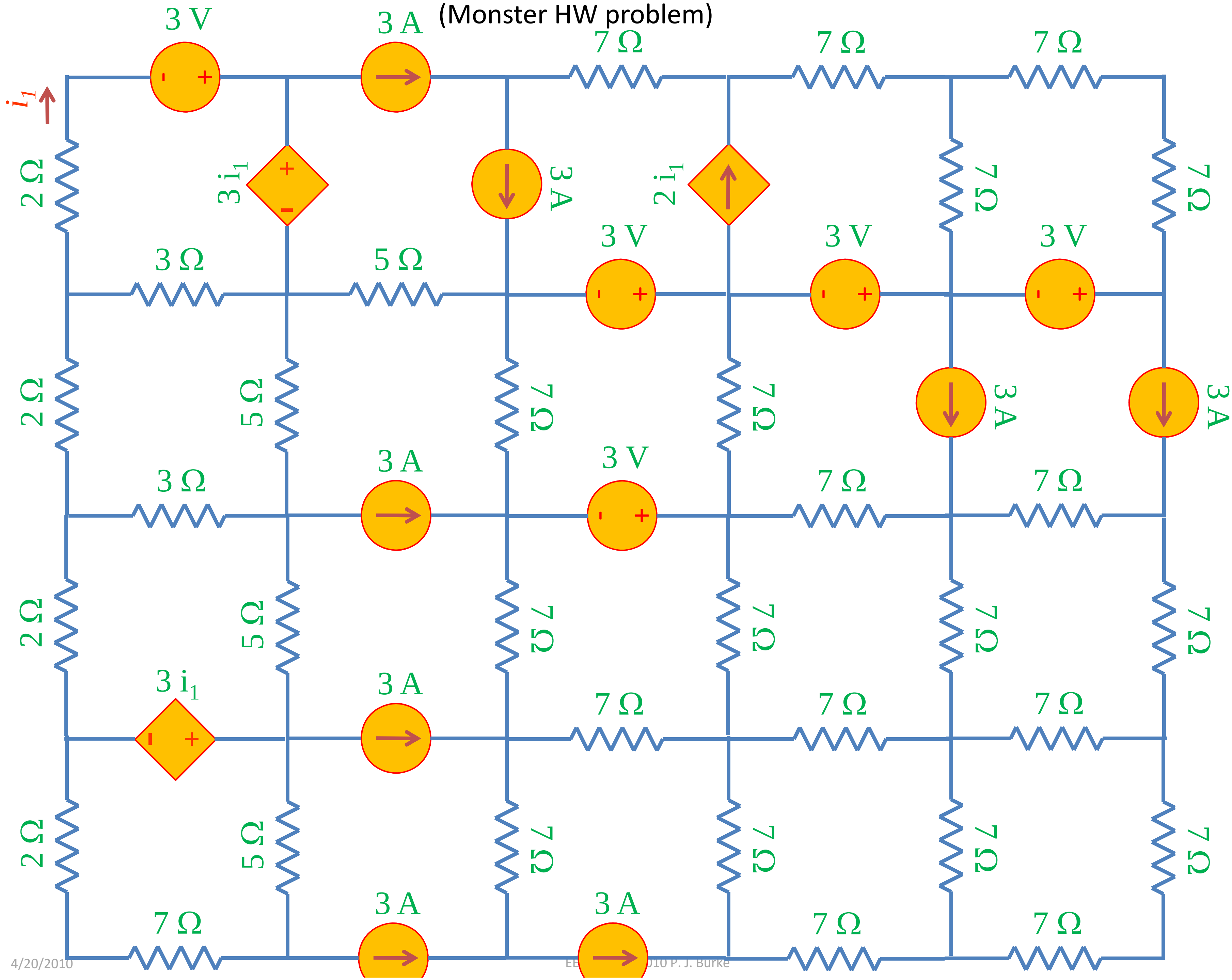

A380 AIRBUS
←E
AIRLINERS.NET

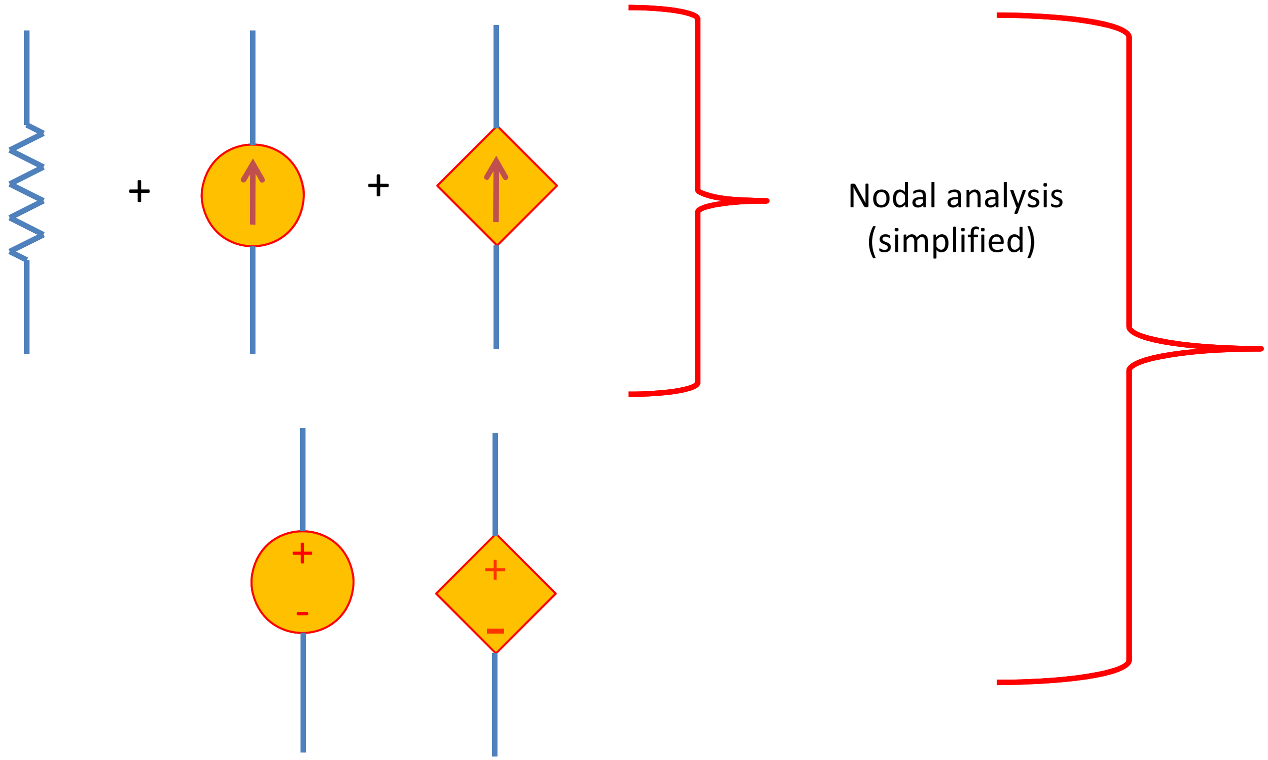

A
Normal heart rhythm recording (EKG)
R
P
T
Q
S
B
Nurse monitoring EKG procedure
Heart rhythm recorded on a machine to produce an electrocardiogram (EKG)
Electrodes connected to EKG machine
Electrodes attached to chest, upper arms and legs


Sold Out


Wi Fi
LINKSYS
CREATIV
N252

(Monster HW problem)

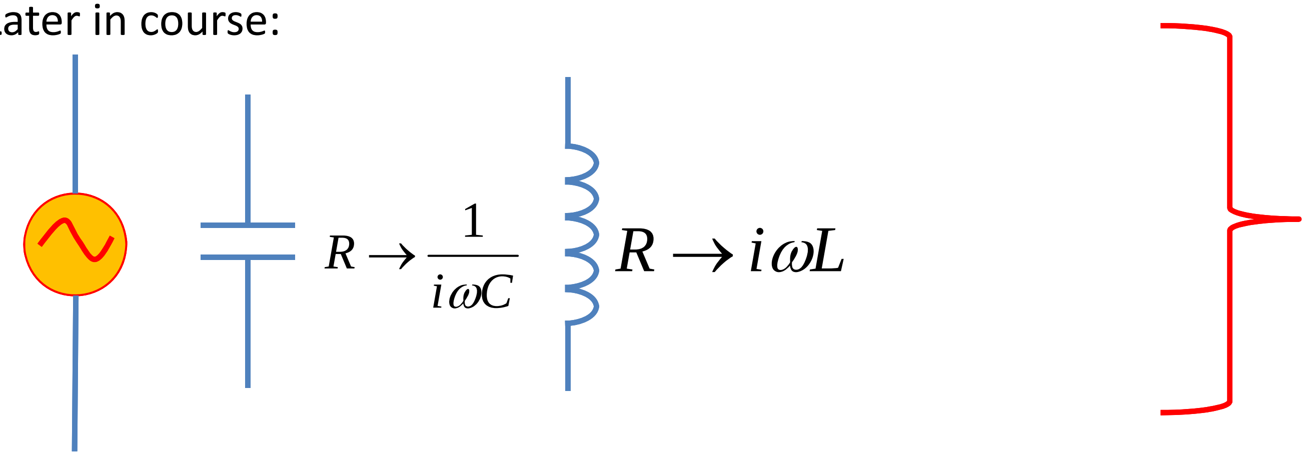




Nodal analysis (simplified)

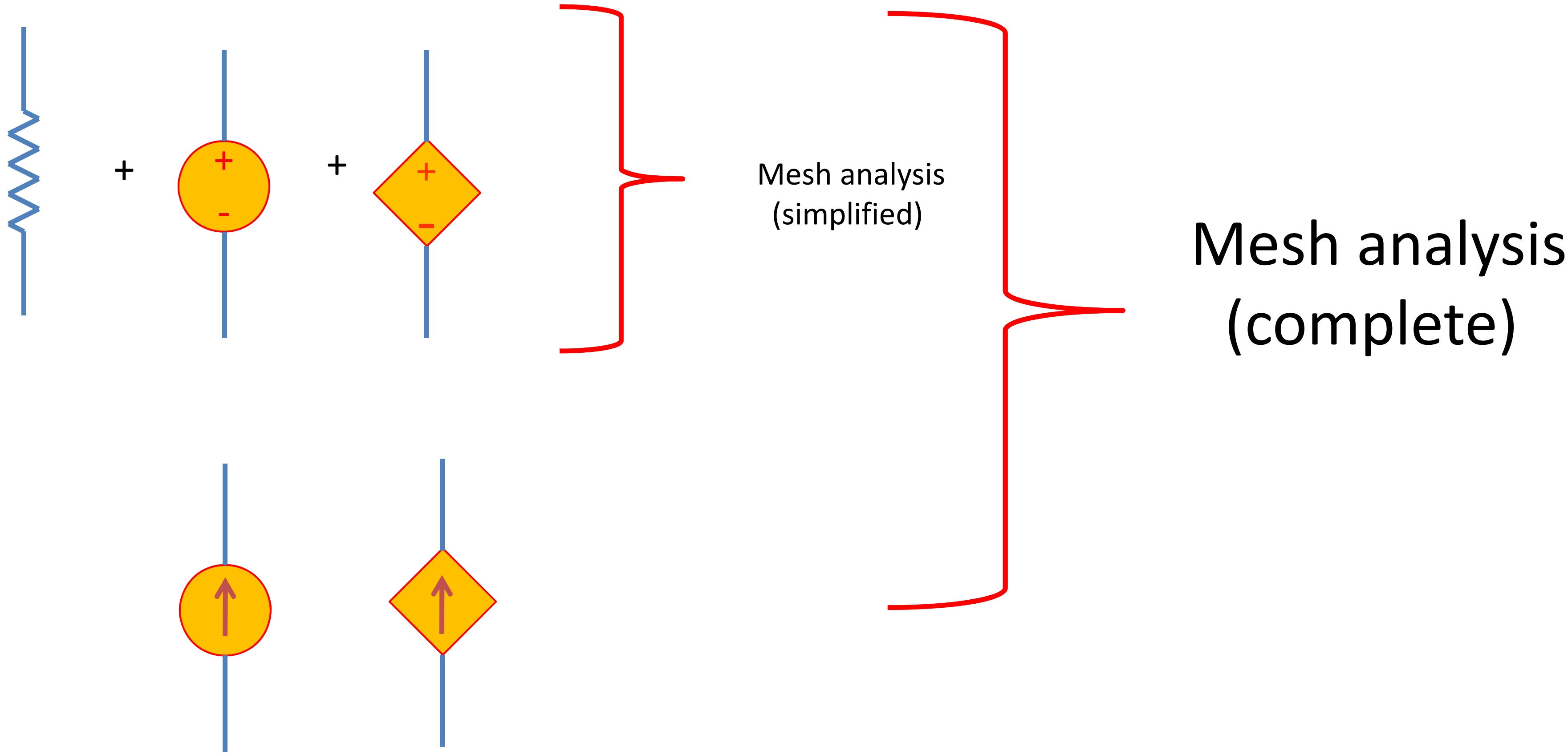
Nodal analysis (complete)

Later in course:

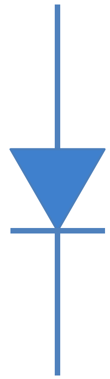


$R \rightarrow \frac{1}{i\omega C}$ $R \rightarrow i\omega L$

All our methods can also be used with these elements.


+
+
Mesh analysis
(simplified)
Mesh analysis
(complete)

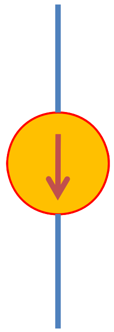
Diode



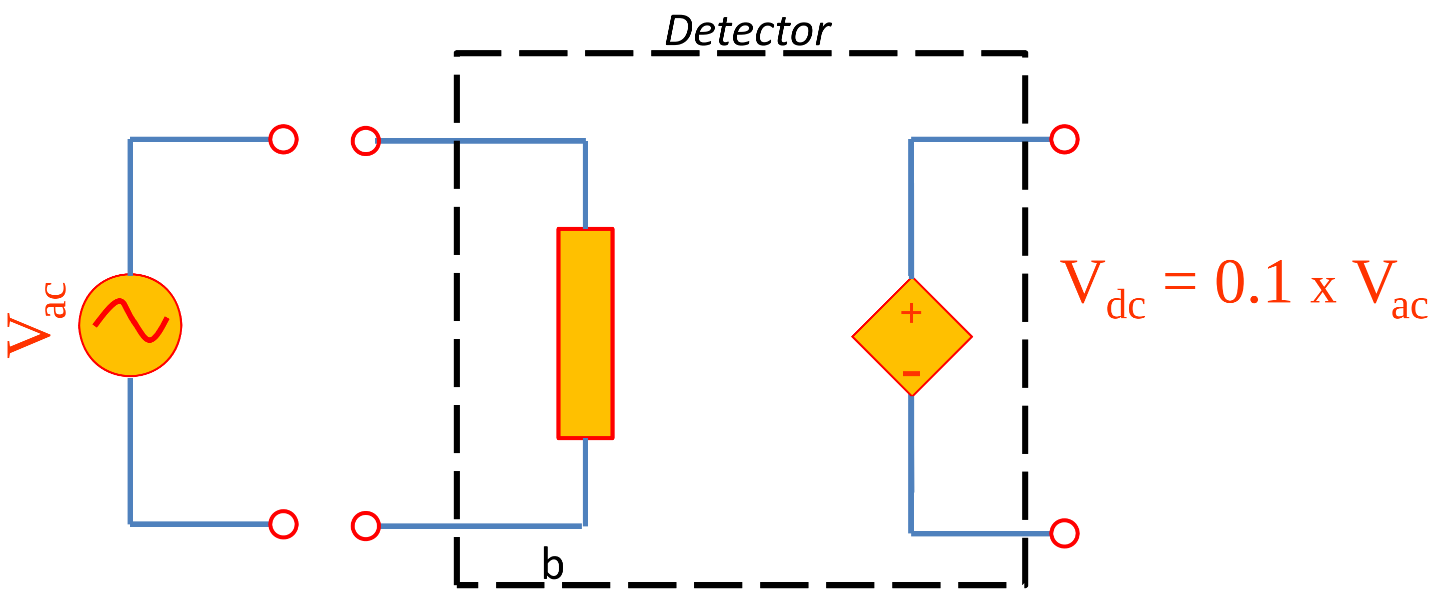
$$I = I_0\left(e^{qV/kT} - 1\right)$$

Nodal/mesh analysis won't work on this but…

Solar cell is a diode.
Behaves like:

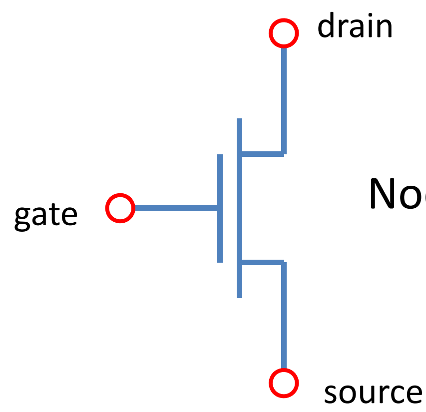


Radio wave detector is a diode.
Behaves like:



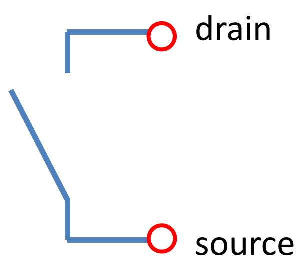
Nodal/mesh analysis works on these equivalent circuits!

Transistors



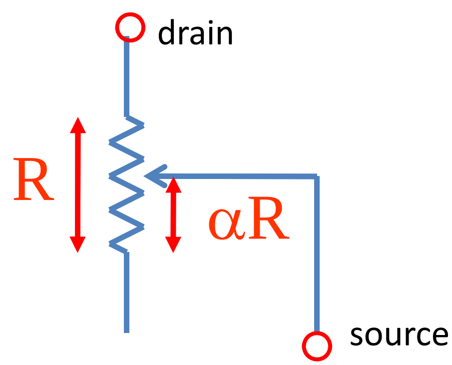
Nodal/mesh analysis won't work on this but...

In some cases behaves like *switch*:



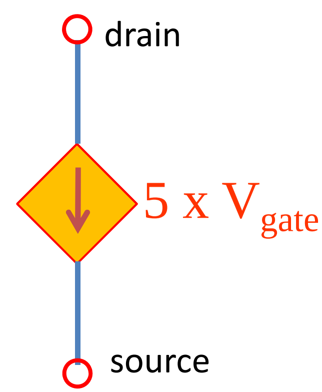
V_{gate}	Switch
+ 5 V	Open
0 V	Closed

In some cases behaves like *potentiometer*:



$$R_{sd} = (constant) \ x \ V_{gate}$$

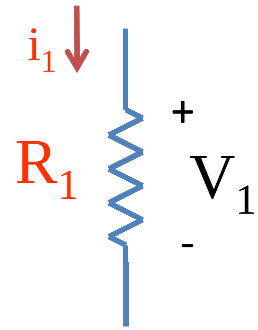
In some cases behaves like *VCCS*:

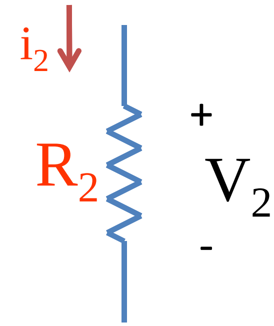


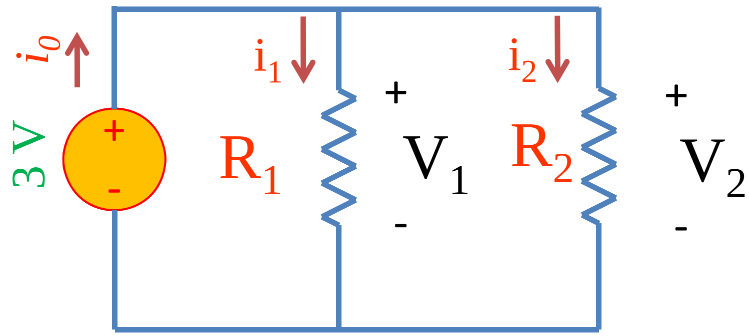
Nodal/mesh analysis works on these equivalent circuits!

Nodal vs. mesh analysis

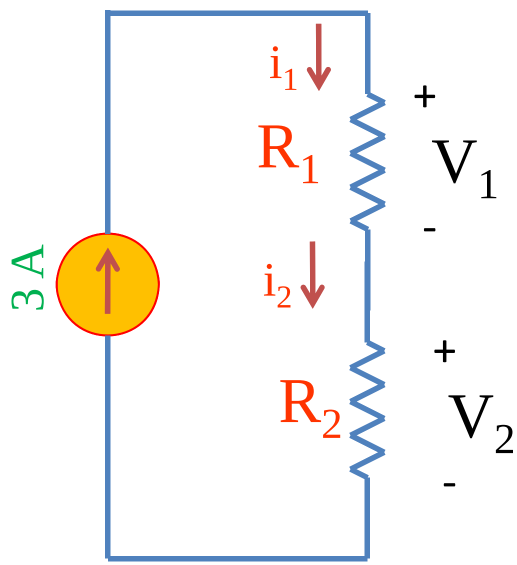
Consider 2 examples, each with 2 resistors.
For both problems, find i_1, i_2, V_1, V_2.
Is it easier to solve for the currents or the voltages first?





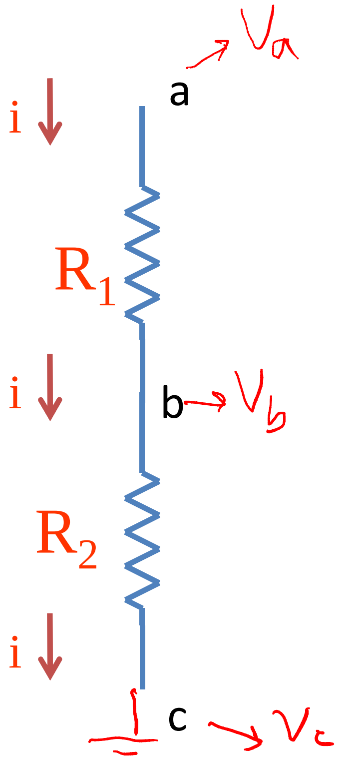


$V_1 = V_2 = 3V$



$i_1 = i_2 = 3A$

Notation: two elements in series

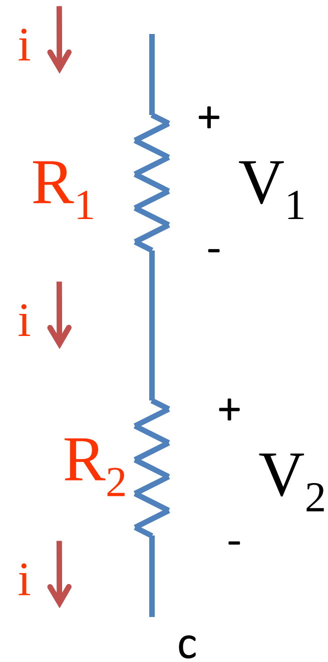


$$i = \frac{V_{ab}}{R_1} = \frac{V_a - V_b}{R_1}$$

$$i = \frac{V_{bc}}{R_2} = \frac{V_b - V_c}{R_2}$$

V_{ab} is the voltage drop across resistor 1

Textbook chapter 2 notation:



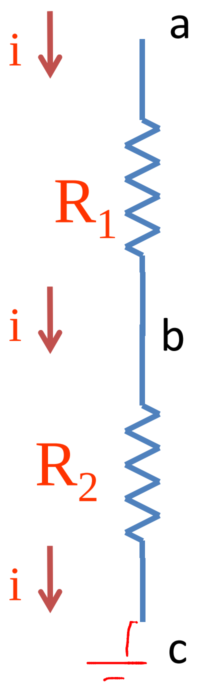
$$i = \frac{V_1}{R_1}$$

$$i = \frac{V_2}{R_2}$$

V_1 is the voltage drop across resistor 1

Nodal analysis

1. Define a reference node.
2. Label remaining nodes



$$i = \frac{V_{ab}}{R_1}$$

$$i = \frac{V_{bc}}{R_2}$$

$V_c = 0v$, $V_a = 5v$, $V_b = 3v$

$V_{ab} = V_a - V_b = 5v - 3v = 2v$

$V_{bc} = 3v - 0v = 3v$

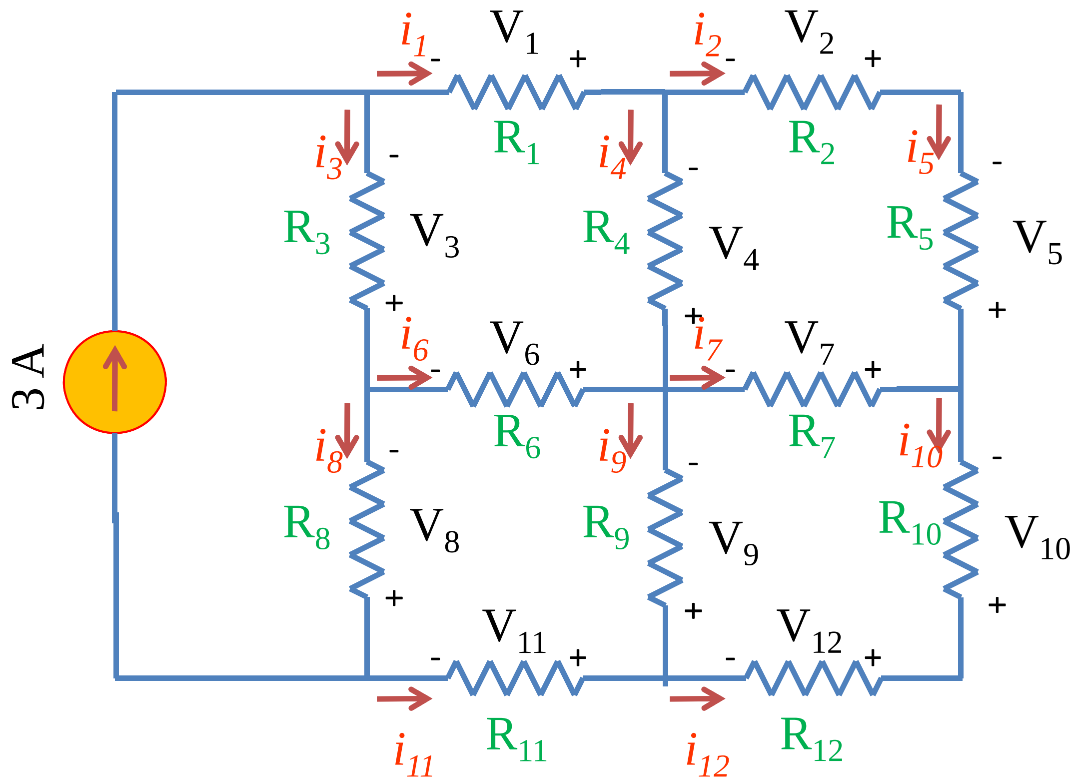
$V_b = 0$, $V_{ab} = 2v$, $V_{bc} = 3v$

$V_{ab} = V_a - V_b = 2v \Rightarrow V_a = 2v$

$V_{bc} = V_b - V_c = 3v \Rightarrow V_c = -3v$

V_{ab} is the voltage drop across resistor 1

Example (Ch. 2 notation)



Label voltages as drops across resistors.

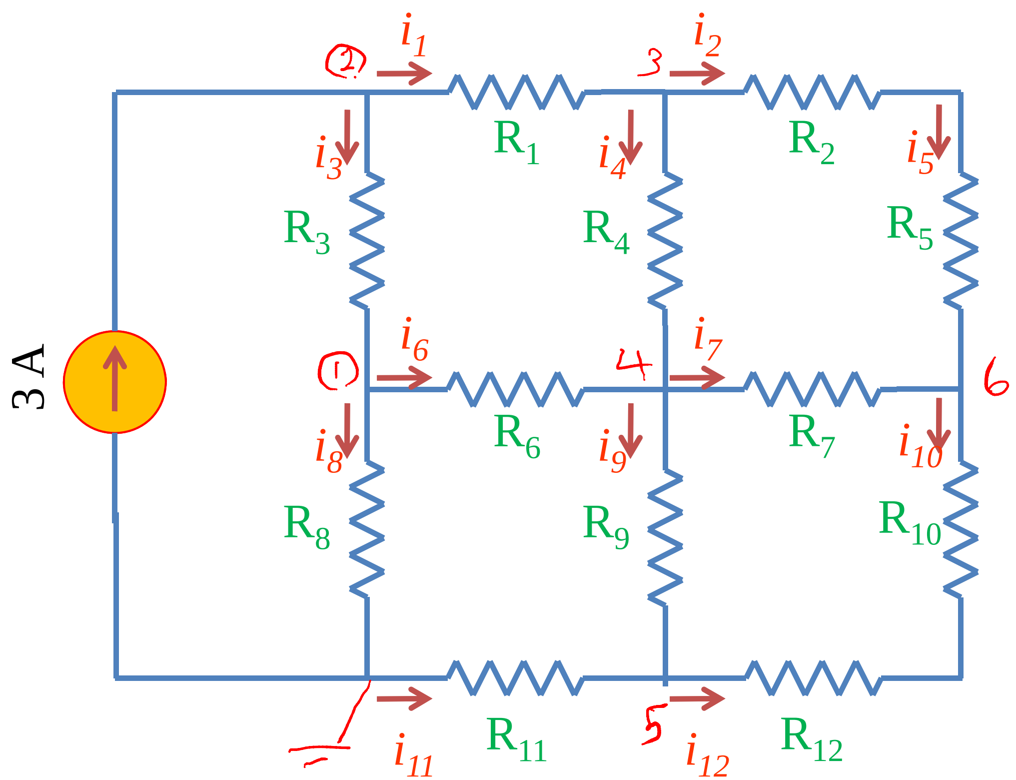
Typical notation:

V_1 is voltage drop across R_1.

i_1 is current through R_1.

Same circuit: Nodal analysis

1. Define a reference node.
2. Label remaining nodes.
3. Apply KCL + ohm.



① $i_8 + i_6 - i_3 = 0$

$$\frac{V_1 - 0}{R_8} + \frac{V_1 - V_4}{R_6} - \frac{V_2 - V_1}{R_3} = 0$$

n nodes → $n-1$ KCL

Typical notation:

i_1 is current through R_1. (Same as before)

V_1 is voltage of node 1 relative to reference node. (Different from before)

Kramer's rule

Solve for x,y,z in terms of known constants $a_{1\text{-}3}$, $b_{1\text{-}3}$, $c_{1\text{-}3}$, $d_{1\text{-}3}$:

$$a_1x + b_1y + c_1z = d_1$$

$$a_2x + b_2y + c_2z = d_2$$

$$a_3x + b_3y + c_3z = d_3$$

x, y, z are node voltages

$$\begin{bmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} d_1 \\ d_2 \\ d_3 \end{bmatrix}$$

$$x = \frac{\Delta_1}{\Delta} = \frac{\begin{vmatrix} d_1 & b_1 & c_1 \\ d_2 & b_2 & c_2 \\ d_3 & b_3 & c_3 \end{vmatrix}}{\begin{vmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix}}, \quad y = \frac{\Delta_2}{\Delta} = \frac{\begin{vmatrix} a_1 & d_1 & c_1 \\ a_2 & d_2 & c_2 \\ a_3 & d_3 & c_3 \end{vmatrix}}{\Delta}$$

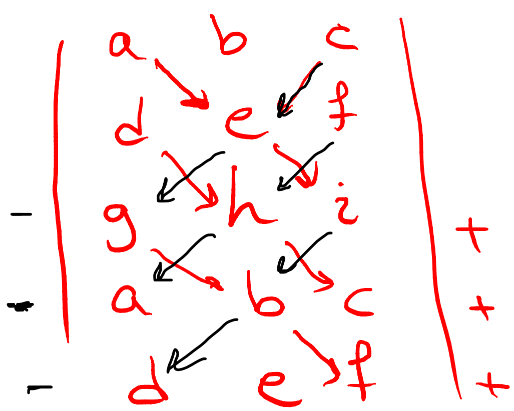
$$z = \frac{\Delta_3}{\Delta} = \frac{\begin{vmatrix} a_1 & b_1 & d_1 \\ a_2 & b_2 & d_2 \\ a_3 & b_3 & d_3 \end{vmatrix}}{\Delta}$$

Determinants:

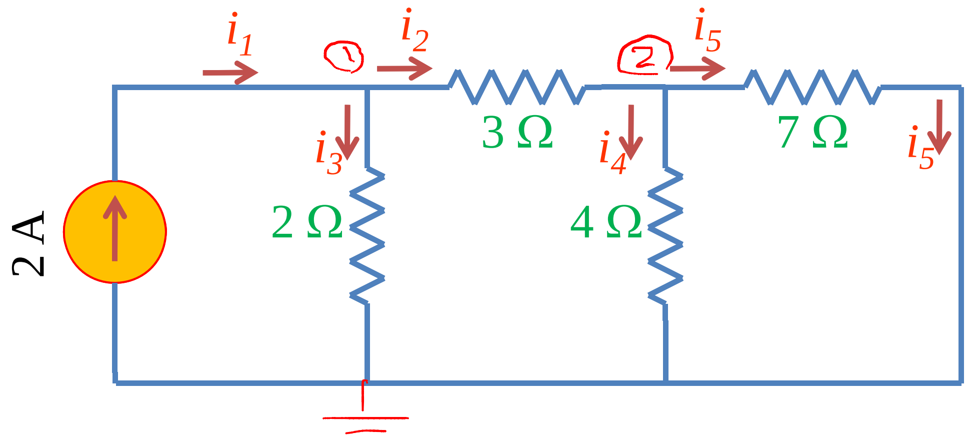
Solve for x,y,z in terms of known constants $a_{1\text{-}3}$, $b_{1\text{-}3}$, $c_{1\text{-}3}$, $d_{1\text{-}3}$:

$$\begin{vmatrix} a & b \\ c & d \end{vmatrix} = ab - cd \qquad ad - bc$$

$$\begin{vmatrix} a & b & c \\ d & e & f \\ g & h & i \end{vmatrix} = \ldots \qquad a\begin{vmatrix} e & f \\ h & i \end{vmatrix} - b\begin{vmatrix} d & f \\ g & i \end{vmatrix} + c\begin{vmatrix} d & e \\ g & h \end{vmatrix}$$



Nodal analysis example



① $-i_1 + i_3 + i_2 = 0$

$* \quad 2A + \frac{V_1}{2\Omega} + \frac{V_1 - V_2}{3\Omega} = 0$

② $-i_2 + i_4 + i_5 = 0$

$** \quad \frac{V_2 - V_1}{3\Omega} + \frac{V_2}{4\Omega} + \frac{V_2}{7\Omega} = 0$

$* \rightarrow V_1\left(\frac{1}{2} + \frac{1}{3}\right) - \frac{V_2}{3} = -2 \xrightarrow{\times 6} 5V_1 - 2V_2 = -12$

$** \rightarrow \frac{-V_1}{3} + V_2\left(\frac{1}{3} + \frac{1}{4} + \frac{1}{7}\right) = 0 \xrightarrow{84} -28V_1 + 61V_2 = 0$

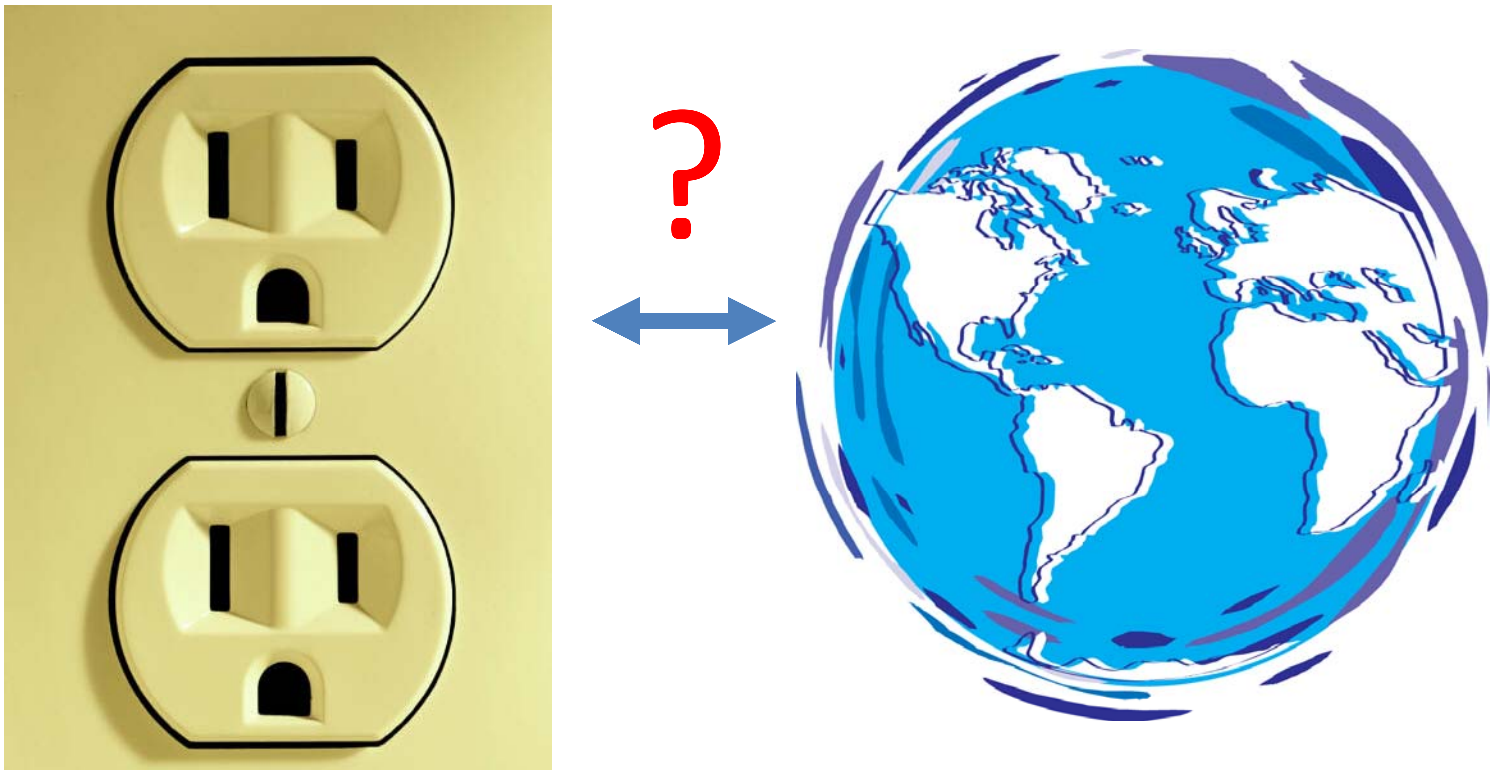
$$V_1 = \frac{\Delta_1}{\Delta} = \frac{\begin{vmatrix} -12 & -2 \\ 0 & 61 \end{vmatrix}}{\begin{vmatrix} 5 & -2 \\ -28 & 61 \end{vmatrix}} = \frac{-12 \times 61 - 0}{5 \times 61 - (-2) \times (-28)} = \frac{732}{249} = 2.93\,V$$

$$V_2 = \frac{\Delta_2}{\Delta} = \frac{\begin{vmatrix} 5 & -12 \\ -28 & 0 \end{vmatrix}}{249} = \frac{0 - (-12) \times (-28)}{249} = 1.35\,V$$

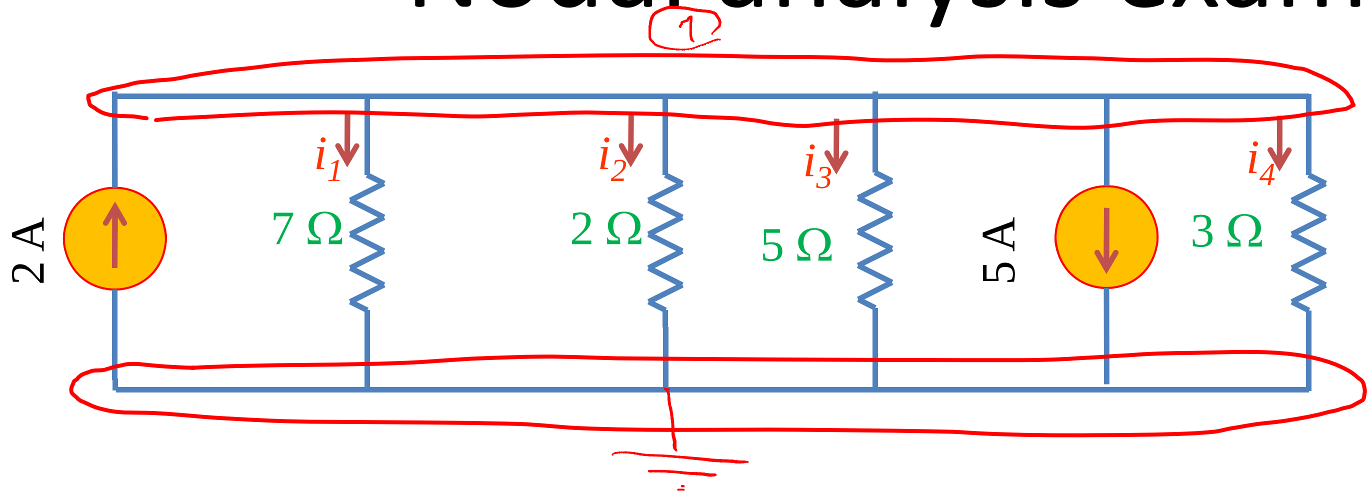
$i_3 = \frac{2.93V}{2\Omega}$

$i_2 = \frac{V_1 - V_2}{3\Omega} = 0.53A$

Ground?



Nodal analysis example



KCL : $i_1 + i_2 + i_3 + i_4 + 5A - 2A = 0$

$$\frac{V_1}{7} + \frac{V_1}{2} + \frac{V_1}{5} + \frac{V_1}{3} + 5 - 2 = 0$$

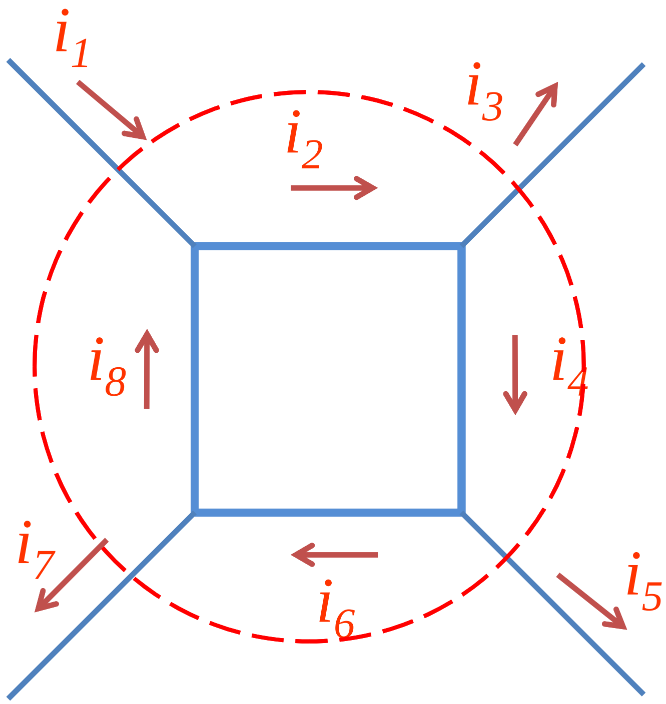
$$V_1 \left(\frac{1}{7} + \frac{1}{2} + \frac{1}{5} + \frac{1}{3} \right) = -3$$

$$V_1 = -2.5\,V$$

Questions?

KCL examples

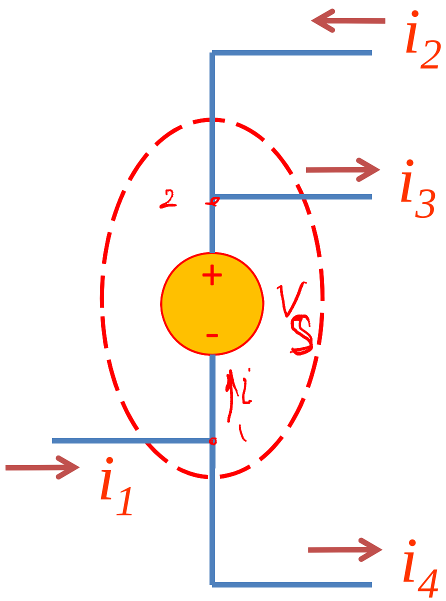
From Lecture 3, Week 2: Find a relationship among $i_1, i_2, i_3, i_4 \ldots$



$i_1 = i_7 + i_5 + i_5$

"Supernode"

A node with a voltage source in it…



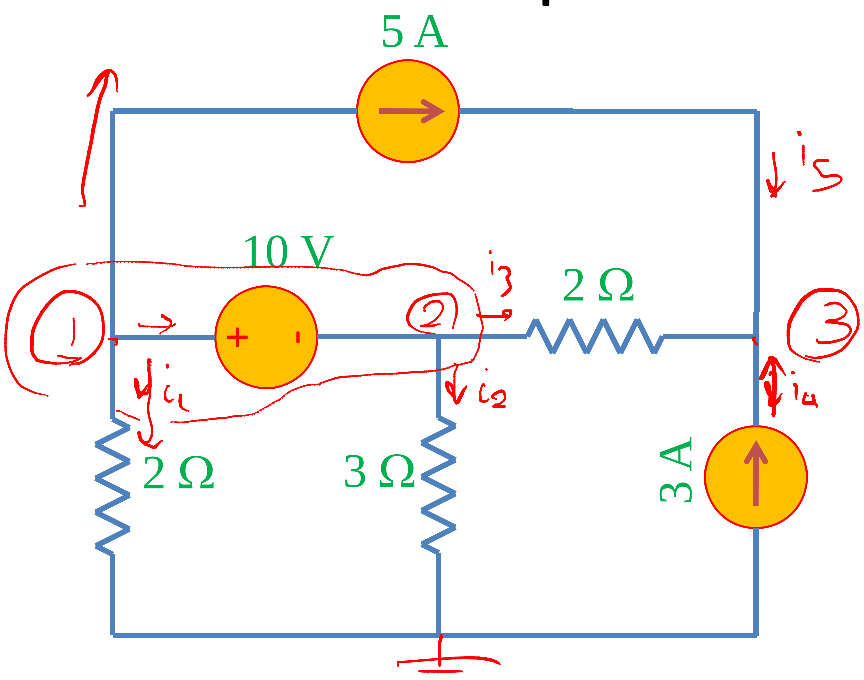
KCL: $i_1 + i_2 = i_3 + i_4$

$\rightarrow V_2 - V_1 = V_S$

Must define a supernode if a voltage source appears when doing nodal analysis…
(unless one end of voltage source connected to reference node)

1. Define a reference node.
2. Label remaining nodes.
3. Apply KCL + ohm to all nodes and supernodes
4. Apply KVL to loop with voltage source

Example nodal w/voltage source



③ $-i_3 - i_5 - i_4 = 0$

$$-\frac{V_3 - V_2}{2} - 5 - 3 = 0 \quad *$$

$$5 + i_3 + i_2 + i_1 = 0$$

$$5 + \frac{V_2 - V_3}{2} + \frac{V_2}{3} + \frac{V_1}{2} = 0 \quad **$$

$$V_1 - V_2 = 10\,V \quad ***$$

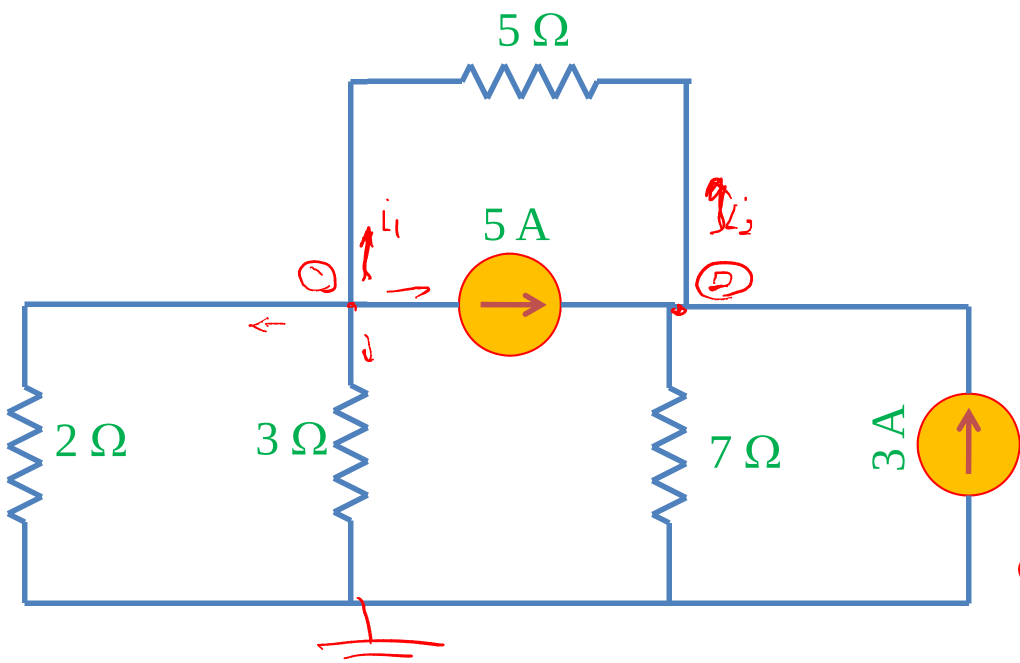
$$V_1 = 10 + V_2 \xrightarrow{\text{r. } **} \begin{cases} 5 + \frac{10 + V_2}{2} + V_2\left(\frac{1}{2} + \frac{1}{3}\right) - \frac{V_3}{2} = 0 \\ -\frac{V_3}{2} + \frac{V_2}{2} = 8 \end{cases}$$

$V_2 = -2.4\,v$, $V_3 = 13.6\,v$

$V_1 = 7.6\,v$

Questions?

Example nodal w/voltage source



① $\frac{V_1}{2} + \frac{V_1}{3} + \frac{V_1 - V_2}{5} + 5 = 0$

$V_1\left(\frac{1}{2} + \frac{1}{3} + \frac{1}{5}\right) - \frac{V_2}{5} = -5$

$31V_1 - 6V_2 = -150$

② $\frac{V_2 - V_1}{5} + \frac{V_2}{7} - 5 - 3 = 0$

$-\frac{V_1}{5} + V_2\left(\frac{1}{5} + \frac{1}{7}\right) = 8$

$-7V_1 + 12V_2 = 280$

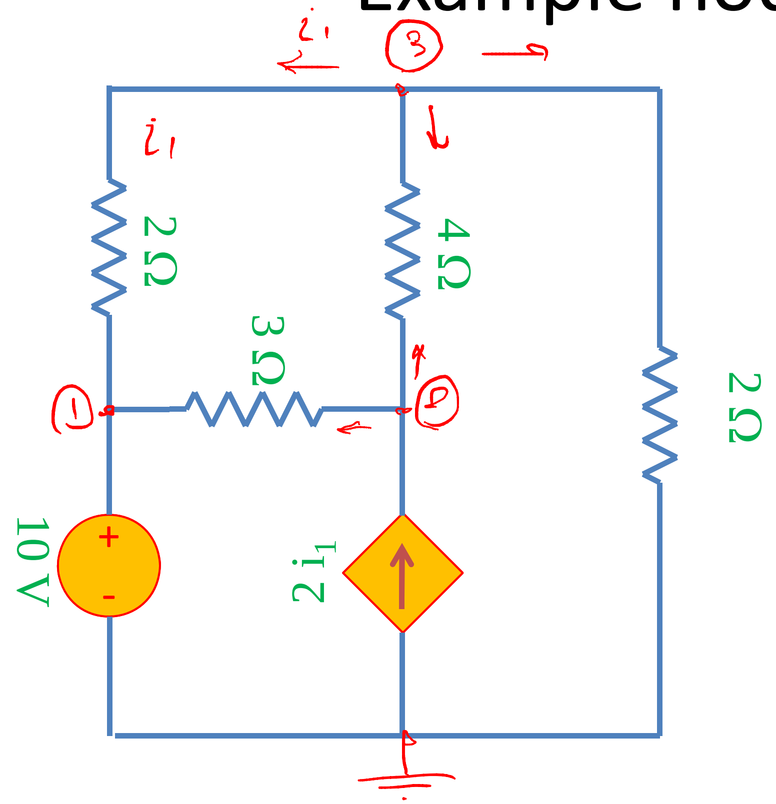
$\times 2$: $62V_1 - 12V_2 = -300$

$31V_1 - 6V_2 = -150$

$-7V_1 + 12V_2 = 280$

$55V_1 = -20 \rightarrow V_1 = \frac{-20}{55}$

Example nodal w/voltage source



$V_1 = 10\text{ V}$

(3) → $\frac{V_3 - V_1}{2} + \frac{V_3 - V_2}{4} + \frac{V_3}{2} = 0$

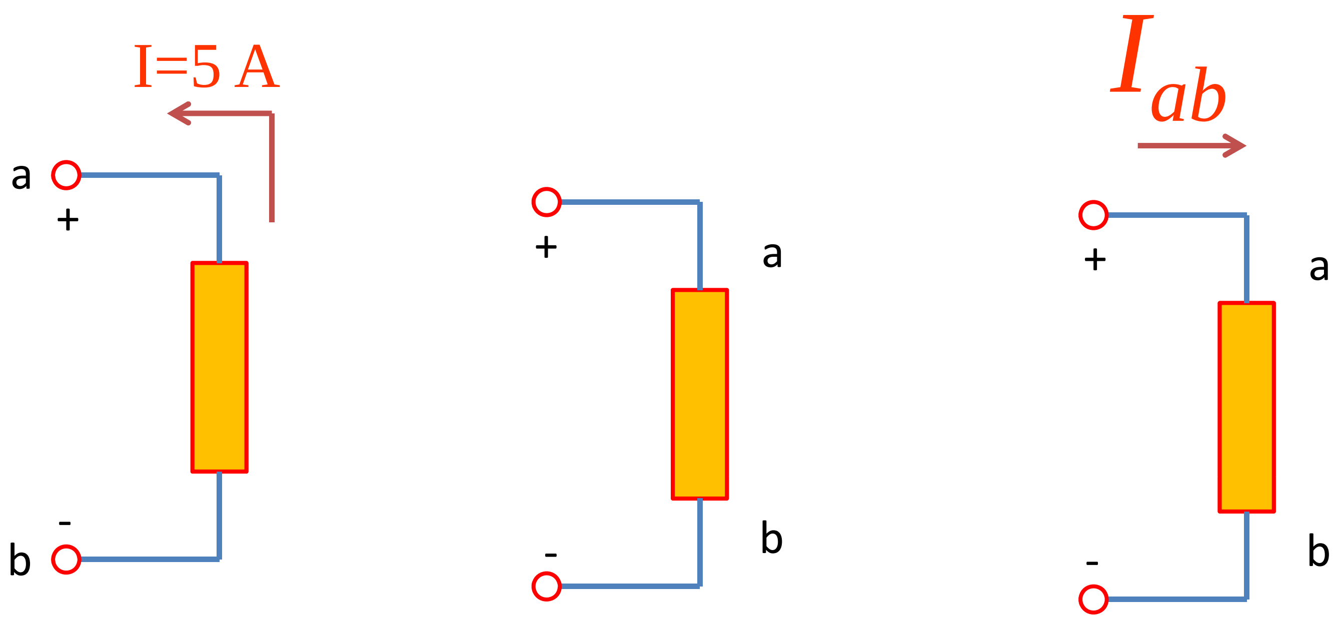
→ $-V_2 + 5V_3 = 20$ *

(2) $\frac{V_2 - V_1}{3} + \frac{V_2 - V_3}{4} - 2i_1 = 0$, $i_1 = \frac{V_3 - 10}{2}$

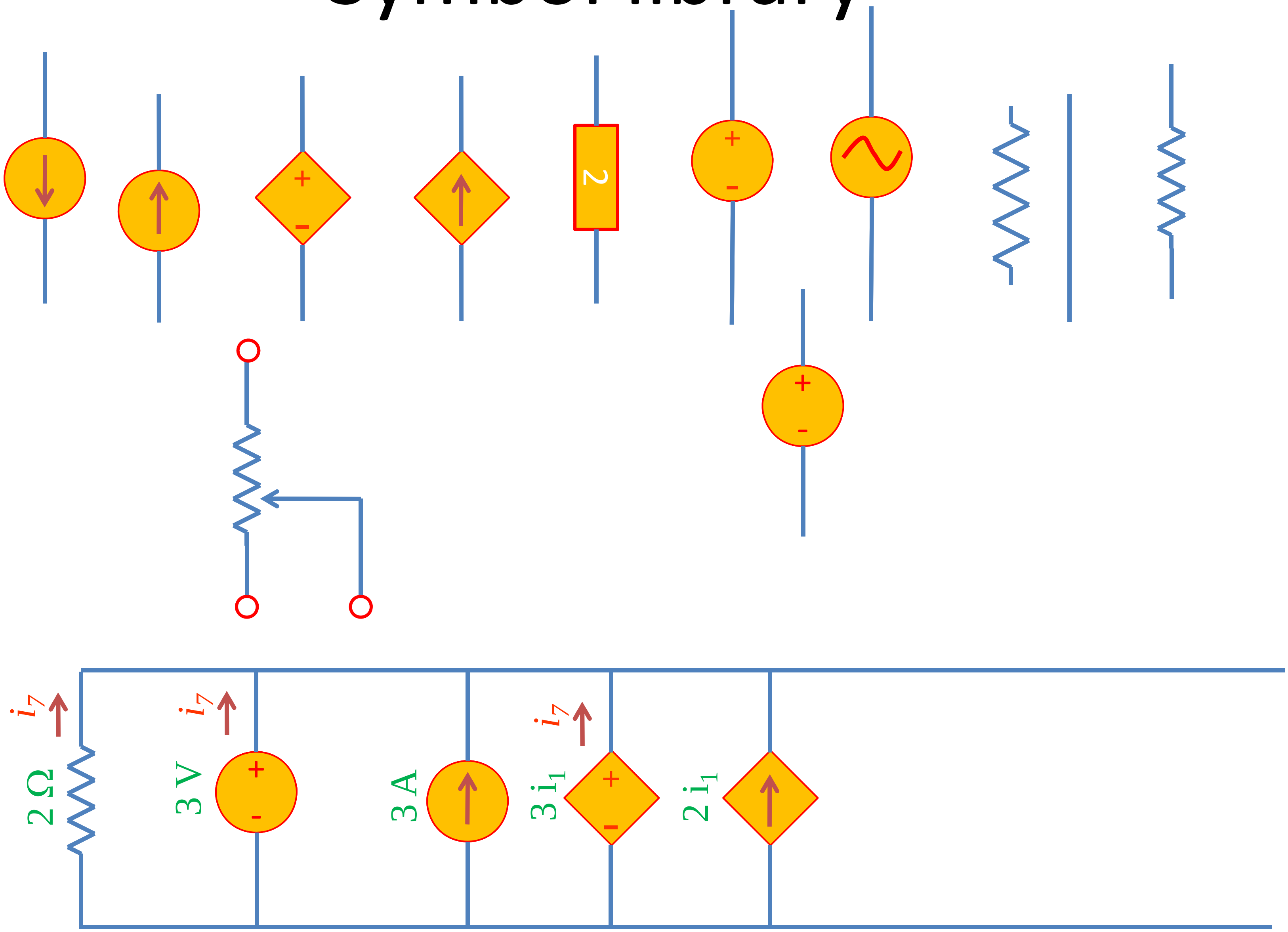
→ $7V_2 - 15V_3 = 52$ **

$V_2 =$

Symbol library



Symbol library



Symbol & circuit library